A BIBLIOGRAPHICAL SURVEY OF LARGE-SCALE SYSTEMS

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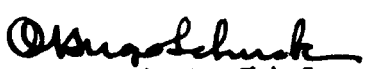
FOREWORD

It is becoming increasingly clear that technology must serve man in improving the quality of life. This identifies the most important future role for control systems engineering, according to the respondents to a survey conducted by the Office of Control Theory and Application in the Fall of 1968. A report of that survey was published as NASA-ERC-PM-67. A symposium in early 1969 brought together leaders in broad application fields to discuss needs with control systems experts. The proceedings of this symposium were published as NASA SP-211. Since then various other means have been used to bring these insights and their implications for action to the attention of larger numbers of control systems workers.

Control systems engineering is seen to have a role in modern society that goes far beyond its traditional one of providing designs for relatively simple mechanistic systems, or even those incorporating a human operator. Complex, large-scale systems are the order of the day, and these increasingly involve aggregates of human beings.

Many attempts have been and are being made by workers in various special fields to analyse their large-scale systems through the use of models. The skills of control systems engineers - in analytic design, in modelling, and in simulation - can be integrated with the skills of specialists in the social areas to meet the problems of life on this planet.

This bibliography is a small start on bringing to the attention of all interested in large-scale systems the experience that has recently been accumulated. It is offered without apology for its inadequacies. Rather, it is offered with the hope that it will be initially helpful to those trying to get started in this most important area.



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ABSTRACT

A limited,partly annotated bibliography was prepared on the subject of large-scale system control. Approximately 400 references are divided into thirteen application areas, such as Large Societal Systems and Large Communication Systems. A first-author index is provided.

TABLE OF CONTENTS

DEFINITION OF THE LARGE-SCALE SYSTEM

A large-scale system is one that is so large that it usually must be controlled by rule-of-thumb or heuristic techniques because one or more of the following conditions exists:

1. The number of parameters necessary to describe the system is too large to handle with conventional models and/or computing techniques.
2. The laws relating the parameters are not well understood.
3. The system is apparently irrational.

Note that sheer physical size is not a criterion for a large-scale system; rather complexity and inability to "get a handle" on the system are more significant.

Naturally there is a frontier zone between small-scale systems, which we can encompass theoretically, and large-scale systems which give us trouble in this respect. As new techniques of modelling, simulation, and analysis are created, this frontier zone moves forward into the region of more complex systems. It is in this frontier zone where excitement exists today, for here new ways of dealing with large-scale systems are being created.

It is well that theorists are paying more attention to large-scale systems because many of the world's most trying problems involve large-scale systems: the national

economy, the American welfare system, the American educational system, even our natural environment, all are large-scale systems. We must learn how to control these systems if society is to survive. At the moment, it appears that many large-scale systems, especially those involving society, are not under adequate control.

OBJECTIVES OF THE SURVEY

The objective of this survey was to make a preliminary sweep of likely sources of reports dealing with the control of large-scale systems. Where papers and reports could be easily obtained, remarks accompany the bibliographical material. The reader is hereby warned that, lengthy as the following bibliography is, it is certainly far from complete. It is hoped, however, that the key papers in every field have been found.

The present-day fragmentation of the field of large-scale systems is the major reason for embarking upon this survey. It was apparent to NASA that little effort was being made to bring together the results from the various programs dealing with large-scale systems, especially societal systems. The very strong shift of American technology into societal programs has stimulated a great deal of systems analysis dealing with cities, the environment, transportation networks, etc. It is the same old story

of people in various fields of endeavor, each unaware of the other, trying to cope with common problems. In this case, the applications themselves are often radically different but the theoretical tools; analysis, simulation, and modelling; are the same. The parameters have different names but there are a great many of them,and they are interrelated in complex ways whether we talk about U.S. power grids or air pollution control on a national basis.

By bringing these references from so many disparate sources together in one place we hope to show the fragmented groups how other people are tackling the same sorts of problems. "Cross fertilization" has become a hackneyed word in management lingo, but cross fertilization is the main intent of this survey.

SOURCES SEARCHED

The routine portion of the literature search began with a survey of the two NASA-supported abstract journals for the period from January 1967 to October 1969: *International Aerospace Abstracts* and *Scientific and Technical Aerospace Reports*. Because these journals do not include all government work of possible interest, *Government and Research Reports* was checked for the same period. The 1968 edition of *Books in Print* was also examined. Another technique applied with good success was the search of recent journals

in the control field for key review and survey papers. Often as not, these papers would refer to older reports. To supplement references acquired through more or less conventional techniques, about fifty letters were posted to scientists and engineers known to be active in the field of large-scale system control. Inquiries were also sent to government agencies and private companies applying large-scale system concepts to societal problems. The preliminary nature of this survey should be obvious from the limited selection of source materials. Despite these restrictions, a rather large amount of pertinent material was discovered.

AVAILABILITY OF GOVERNMENT REPORTS CITED

Government reports cited in this report may be obtained from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151. Prices are 65¢ each for microfiche and $3.00 each for hard copies. NASA and Department of Defense contractors can also obtain reports sponsored by these organizations from the following information centers:

NASA Scientific and Technical Information Facility
P.O. Box 33
College Park, Maryland, 20740

Defense Documentation Center
Cameron Station
Alexandria, Virginia, 22314

The reports thus available bear the following codes:

AD-000000	Department of Defense
JPRS-00000	Joint Publications Research Service
NOO-00000	National Aeronautics and Space Administration
PB-000000	Other government agencies.

ORGANIZATION OF THE SURVEY MATERIAL

Except for the first section of references dealing with large-scale system theory, the material in this survey

is categorized by application area, as indicated in the Table of Contents. Specialists can thus readily find reports dealing with their own areas of interest. However, it would defeat one of the main purposes of this report if specialists did not at least browse through other application areas to discover what other people are doing with large-scale systems. A first-author index completes the report.

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